Blog

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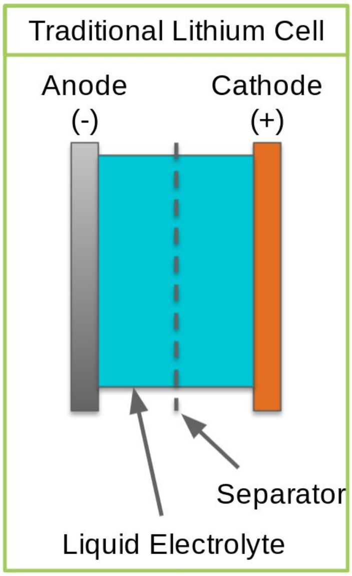
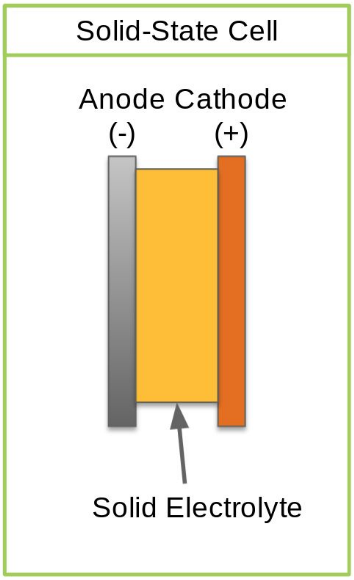
Solid state: the state of play

There is a great deal of attention focused on the prospects of solid-state cells, with many industry players suggesting that they are close to achieving a solution for their use in Light Vehicles. For a number of reasons, however, no commercially viable solid-state cell has yet made its way into the sector.

The principle of a solid-state cell is straightforward. In a conventional lithium-ion cell, there are four components: anode, cathode, separator and electrolyte. A solid-state cell combines the separator and electrolyte into a single, solid item. To the best of our knowledge, this can only be in the form of a polymer or ceramic.





Solid electrolytes reduce dendrite formation. Dendrites are deposits of lithium on the anode that are not absorbed, resulting in spikes that can puncture traditional lithium cell separators, shorting the cell. The reduction of dendrites enables a longer-life cell that can take more load with less fire risk, especially as flammable liquid electrolyte is not used.

Fewer components and tighter anode-cathode spacing reduce the material requirement, allowing for lighter and cheaper, yet more power- and energy-dense cells.

So why, if they are so appealing, are solid-state cells not widely available?

At present, the possibility of the electrolyte cracking or failing over a normal lifecycle appears to be the primary concern; some chemistries can only operate above 55 degrees centigrade, making them impractical for personal vehicle usage.

Once these issues are resolved, the next obstacle will be price, driven by one key problem: the inability to mass manufacture. If ceramic is used, the ‘sandwich’ layer of cathode, anode and ceramic cannot be folded or rolled, so only a pouch format is viable. This in itself is not an issue, but when we consider that the ceramic layer is just microns thick and very brittle, it becomes problematic. Some companies have succeeded in batch manufacturing, using 3D printing to create a three-dimensional cell structure to aid robustness and maintain performance. But, at 30-90 seconds per cell, it is not yet an economically efficient production model when producing thousands of units.

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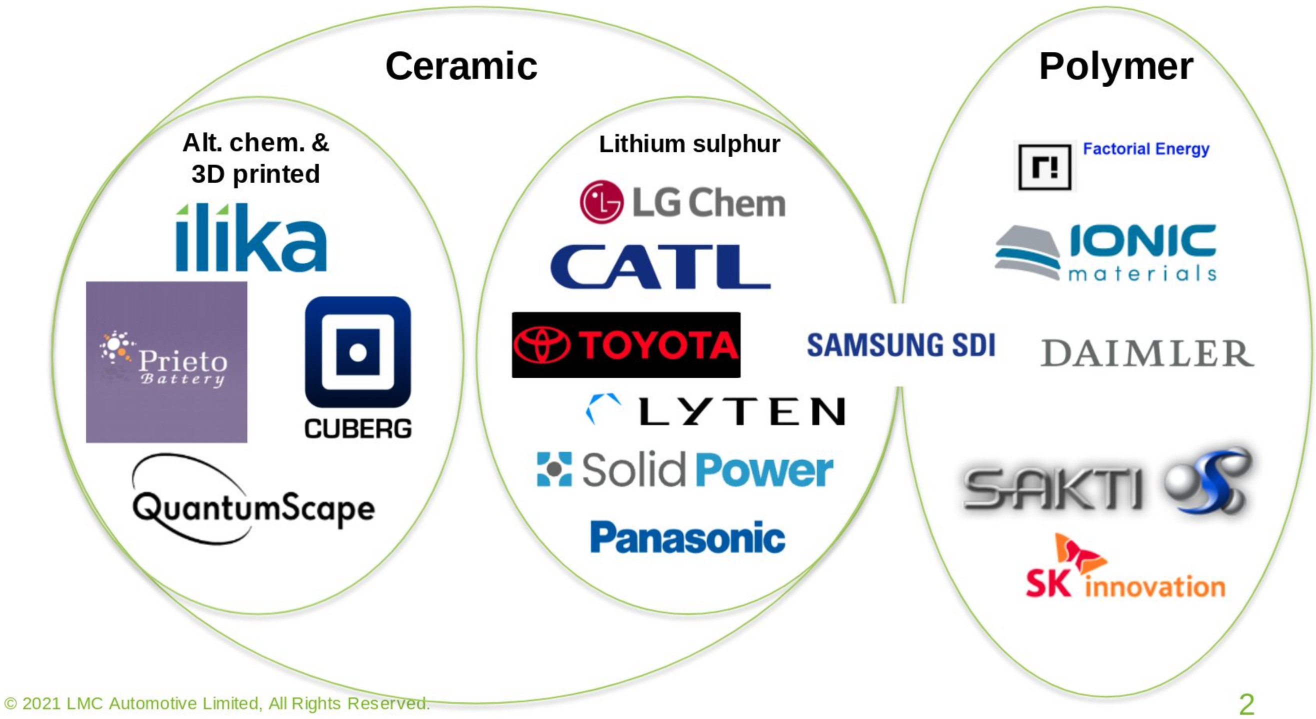
Properties of the ceramic electrolyte can be bonded with a polymer within the cell construction to improve interfaces, cohesion, manufacture and robustness, but this comes at the expense of energy and power density. Utilising a polymer-based electrolyte enables the anode, cathode and electrolyte to be rolled into a cylindrical- or prismatic-shaped cell.

In addition, the inorganic nature of solid electrolytes means that they must be perfectly dry and contaminant-free during the production process. Leaving aside the issues that arise from physical properties, creating a hermetically sealed plant able to manufacture cells on a mass scale is extremely challenging.

To date, most battery suppliers and developers have been very secretive, with any announcements of ‘breakthroughs’ offering little technical detail and no insight as to whether mass production is even feasible for the technology concerned.

The diagram below illustrates which solid-state technology we believe most OEMs are currently investigating.



Among them, only Toyota appears to be preparing to scale up to mass production relatively soon, but as the implementation date has been postponed numerous times, we remain sceptical of a near- or even medium-term application.

In our view, solid-state cells are unlikely to come to fruition until around the tail-end of this decade. But it is worth bearing in mind that our assessment remains fluid, given that this is clearly still an emerging technology.